Prepared Statement of
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Mr. Chairman, thank you for this opportunity to discuss how biofuels can provide our nation with an abundant, renewable source of energy, and in particular, help reduce our dependence on imported oil. I am the director of the National Bioenergy Center at the National Renewable Energy Laboratory, in Golden, Colorado. NREL is the U.S. Department of Energy's primary laboratory for research and development of renewable energy and energy efficiency technologies. I am honored to be here, and to speak with you today.

The committee is to be commended for your hearings on new energy technologies. The director of my national laboratory, Dr. Dan Arvizu, came before you last week to address the entire range of renewable energy technologies that are in the marketplace, and on the horizon. Given the seriousness of the energy challenges we face as a nation, there is a lengthy list of renewable and conventional energy options that must be pursued.

If we narrow our focus, however, and consider specifically just those things we can do to create a viable alternative to oil – then our choices become more limited. Developing an industry to produce biofuels like ethanol and biodiesel must be a priority – because biomass is the only renewable option we have for liquid transportation fuels.

The emerging biofuels industry

Biomass is plant material, most commonly, trees, grasses or agricultural wastes that can be turned into energy. There are a lot of ways biomass can provide energy, and for decades there has been a valuable biopower industry in this country that produces *electricity* from biomass. Your hearing this afternoon on the next generation of vehicle and fuel technologies is timely and appropriate. We only recently have come to fully comprehend just how valuable a contribution ethanol can make, and how we can mobilize the technology and the entrepreneurial wherewithal to make it happen.

Accelerated development of a cellulosic ethanol industry is a goal that I believe realistically can be accomplished – if we put adequate resources behind the effort.

When President Bush came to our Laboratory earlier this year, he talked about a national goal of replacing more than 75% of our oil imports from the Middle East by 2025. And he affirmed that the best way to do that is through increasing our research on advanced energy technologies.

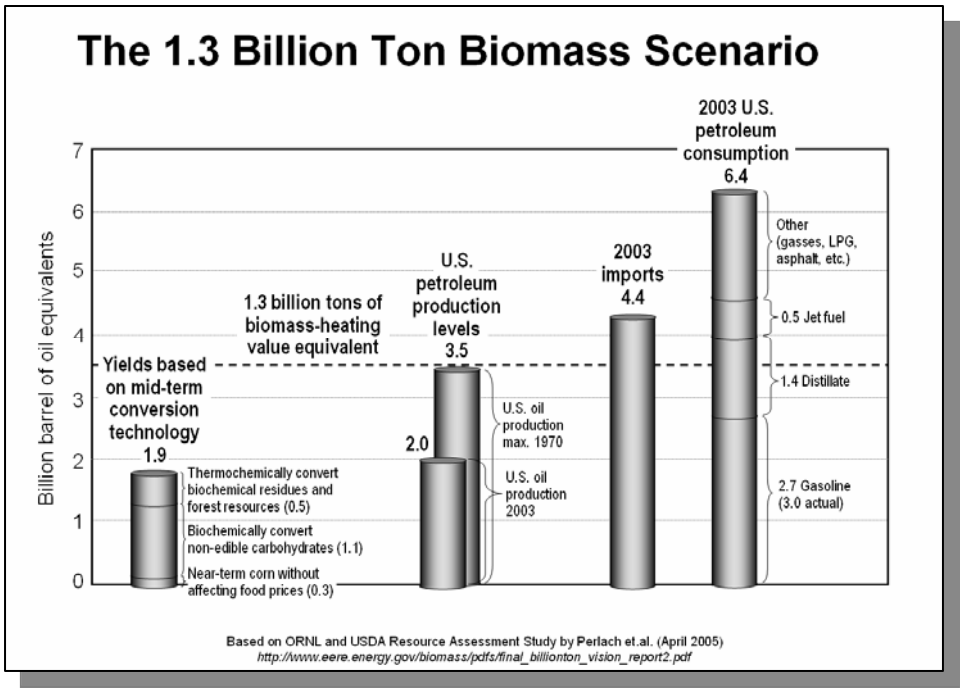
Dr. Arvizu and I were privileged to take the President through one of our key research buildings, the Alternative Fuels User Facility. We toured our process development equipment and I explained what goes on there - the research needed to accelerate the growth of a vital bioenergy industry in the United States.

Our goal is to make renewable biomass-derived fuels and chemicals the solution for ending, as President Bush himself memorably put it, our nation's "addiction" to oil. And with the

President's Advanced Energy Initiative, we are on course to bring the nation's first commercial cellulosic ethanol production facilities into existence by 2012.

Biomass: A plentiful resource

While much remains to be done, we as a nation start with some significant strengths. First, the biomass resource in the country is huge, and the potential for it to grow is significant.



The Department of Agriculture and the Department of Energy recently looked at the question of whether the nation's biomass resource could foster a biofuels industry large enough to meet a significant portion of our nation's future fuel needs. The report, now commonly referred to as "The Billion Ton Study," for the first time confirmed that the U.S. could yield more than a billion tons of biomass annually for energy needs. And, importantly, we could do this without negatively affecting the nation's ongoing needs for food or fiber. This is significant because the 1.3 billion tons of biomass that was forecasted contains as much energy as 3.5 billion barrels of oil.

Let me provide some perspective on that. This 3.5 billion barrels is about 60% of the 6 billion-plus barrels of oil the U.S. consumes each year. Domestically, the United States, including Alaska, currently produces about 2 billion barrels of oil per year. That's only 67 percent of the potential we see from biomass. U.S. oil production peaked in the early 1970s at the same level of production, about 3.5 billion barrels per year. The U.S. has *never* produced more than 3.5 billion barrels a year of oil.

I should emphasize that such a transition to biofuels will not happen overnight. It will take a significant and sustained national effort to get us there. Still, "The Billion Ton Study" clearly demonstrates the biomass resource is real, and large enough to ultimately replace a large fraction of the petroleum-derived fuels we depend on today.

Moreover, the resource is regionally diverse. We envision that every state in the nation could produce biomass and could benefit economically from an expanding biofuels industry.

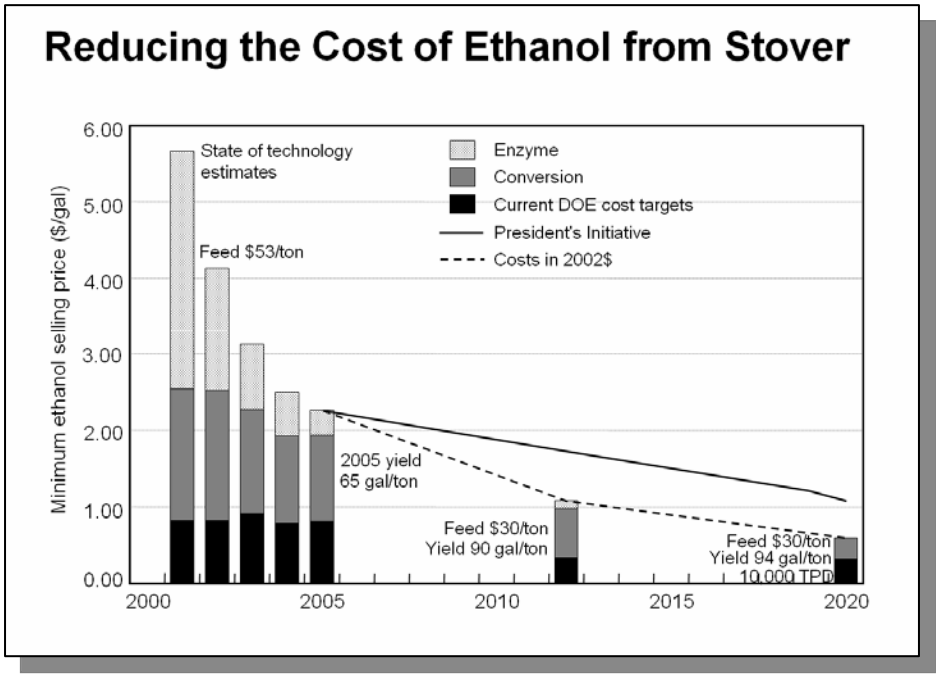
We also are encouraged by the fact that there already exists a strong and growing ethanol fuels industry in this country. The U.S. currently produces more than 4 billion gallons a year of ethanol, almost exclusively from corn grain, and the industry is growing 30 percent annually.

To understand where we are today, and where we need to go, we need to see ethanol technology issues, and biomass resource issues, as interrelated. To move the ethanol industry to where we need it to be, we have to move beyond corn grain as the primary biomass resource. One of the most abundant potential resources we have is corn stover, the non-food parts of the corn plant, including the stalks, leaves and husks. Other resources are forest thinnings, hardy grasses, like switch grass, and fast growing trees.

To use these and other resources we need to perfect new technologies that convert the *cellulosic* materials of the plants into fuel.

Breaking down the economic barriers

So, why aren't we producing ethanol from cellulosic biomass today? Simply put, the cost is too high. If we were to build a facility today for converting cellulosic biomass to ethanol, it would produce ethanol at about twice the price of one of today's existing corn grain ethanol facilities. But we are making steady progress. The focus of the DOE Biomass Program and the National Bioenergy Center is to make cellulosic ethanol as cheap as corn ethanol within the next 6 years. Longer term, DOE and NREL are targeting a cost of cellulosic ethanol as low as 60 cents per gallon, but this will require revolutionary approaches for producing, collecting, and converting biomass.



The targets we have set to accomplish this are ambitious, but we believe they can be met with adequate research support. Our goal is to reduce the cost of producing cellulosic ethanol from $2.25 a gallon in 2005, to $1.07 in 2012. To get there we are working to greatly increase production efficiencies, and boost the average yield from 65 gallons per ton as it is today, to 90 gallons per ton in 2012.

One of the reasons I'm optimistic that we will meet these targets is our encouraging progress to date. Over the past 5 years, we've been able to drastically cut the cost of ethanol from cellulosic

biomass, corn stover in particular, by reducing the cost of enzymes in partnership with two major enzyme manufacturers, and improving the biomass conversion process.

In the late 1990's, the high cost of cellulase enzymes forced the use of an entirely different process called acid hydrolysis, even though the acid hydrolysis process has inherent limitations in what it can yield. That has changed because of a partnership between DOE and NREL, and two of the world's largest bio-engineering firms – Genencor and Novozymes. The consequences of that research collaboration have been impressive. The cost of enzymes for producing cellulosic ethanol has been reduced from more than $3 per gallon of ethanol, to less than 25 cents per gallon. And, we are working to reduce that to 10 cents a gallon by 2012. As a result, all major process development work on cellulosic ethanol production has now turned to more efficient enzymatic hydrolysis – proof that the nascent industry already is benefiting from these scientific breakthroughs.

Integration of biorefineries into existing industries

Another exciting area of work is in the development of what are coming to be called "biorefineries". Our scientists at NREL, together with those at other DOE national laboratories, universities and corporations, are leading the development of fully integrated refineries that use biomass, instead of petroleum, to produce fuels, chemicals, synthetic materials – virtually all of the products we use from a conventional oil refinery today. Biorefineries utilize a complex array of processing facilities to break down, convert and recombine a wide range of biomass components into fuels and chemicals, in a manner similar to how petroleum refineries convert petroleum crude oil. We envision that future biorefineries will utilize a wealth of resources we either underutilize or don't use at all today. That includes agricultural residues, forestry residues, dedicated energy crops, municipal solid waste, algae and by-products of the food and grain industry.

A range of biorefinery R&D work is underway in partnership with industry. As Assistant Secretary Karsner has noted, DOE's biomass program is partnering with a number of the major ethanol technology providers and ethanol producers, including Abengoa, ADM, Broin and Cargill, to increase the yield of ethanol from existing corn ethanol facilities and expand the slate of feedstocks.

At the same time, DOE is partnering with existing chemical industry leaders such as DuPont and Dow Chemical to develop new opportunities for producing both fuels and chemicals from biomass and with NatureWorks to develop biorefineries that co-produce ethanol and polylactic acid, or PLA, a unique environmentally friendly and renewable polymer.

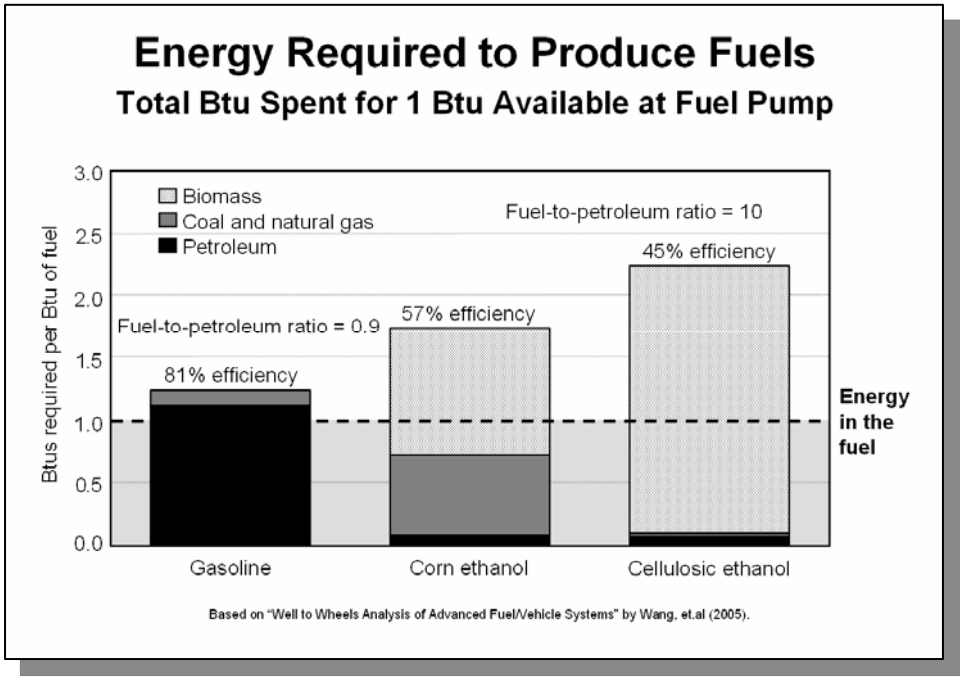
These and other partnerships are speeding the progress of new technologies to the marketplace.

In many ways, a cellulosic biorefinery can be viewed as an expansion of a starch ethanol facility. That's why we believe tomorrow's cellulosic ethanol industry will not replace today's corn grain ethanol industry, it will evolve from it. Similarly, DOE is partnering with the forest products industry to develop biorefinery concepts that can integrate into existing forestry operations.

Ethanol reduces use of petroleum

You may have heard some discussion about the energy efficiency of ethanol. The first ethanol plants built in the late 1970s were costly and energy-intensive, and that did spark a debate about whether it made good "energy sense" to replace gasoline with ethanol. Today's ethanol industry is considerably more cost effective and energy efficient. Researchers at DOE, USDA and elsewhere have shown that the net energy benefits of fuel ethanol are clear and considerable.

The figure below summarizes results from the "Well to Wheels" study conducted by Argonne National Lab, General Motors, and several other partners including two major oil companies. As shown in the figure, the energy contained in ethanol made from corn is about 1.4 times the fossil energy used to produce the ethanol, and 10 times the petroleum used. For cellulosic ethanol, the ratio of energy in the ethanol to the fossil energy used also increases to about 10 Btu's in the ethanol for every 1 Btu of fossil fuel used. From the perspective of science, at least, this debate has been decided in favor of continued development of ethanol. Ethanol is proving to be a very effective option for reducing our dependence on petroleum – regardless of whether it is made from corn or cellulosic materials.



There is little doubt that ethanol will be, and should be, the first biofuel that we can use to reduce our dependence on petroleum. However, NREL and the National Bioenergy Center recognize that other biofuel options need to be developed as well. Biodiesel and other derivatives of fats, oils and greases can make a significant contribution. Aquatic species such as algae can also play a major role in the long term, because they do not require fertile soils, can grow in brackish water, and yet, algae can produce very high yields of oil.

Thermal technologies such as gasification, pyrolysis and hydrothermal systems are all worthy of further research and development to determine how these technologies and the respective biofuel products impact the cost, efficiency and integration into existing fuels infrastructure.

Other NREL vehicles and fuels research

I would be remiss if I did not note the other important research being conducted at NREL which also is contributing to the next generation of vehicles and fuels. NREL's Center for Transportation Technologies and Systems is working on many promising answers to our future transportation needs, including gasoline-electric hybrid systems, new, cleaner diesel fuels and a

number of fuel saving technologies. So-called “plug-in hybrids” are one dramatic example. These vehicles use both a gasoline engine and the electric outlet of your home to eventually achieve fuel economy of more than 100 miles per gallon.

It should be noted that among the benefits of biofuels are some significant advantages regarding air emissions. Both ethanol and biodiesel are oxygenates and hence can reduce the hydrocarbons, carbon monoxide and soot emitted from the tail pipes of gasoline and diesel vehicles. Ethanol additionally can cut by a quarter emissions of smog forming hydrocarbons from fuel evaporation.

Continued research hastens fuels development

In conclusion, let me review some key points: Biomass is the only renewable option for producing liquid transportation fuels. The U.S biomass resource can supply a large portion of demand for gasoline and we can greatly expand the resource base when world petroleum production begins its decline. The biofuels industry can use resources from every region of the country and could become a needed stimulus for ailing rural economies. Ongoing research, like research into biorefineries, will create many new products beyond the biopower, ethanol and biodiesel we are producing today.

The President’s initiative holds the promise of accelerating our work so that we can help get this industry up and running, to benefit the American people, even sooner. His initiative envisions a more aggressive research effort in all key areas: further reductions in enzyme costs, advances in process technology to reduce capital and operating expenses and advances in feedstock R&D that will reduce the cost of production, collection and transportation of biomass to the biorefinery.

As director of the nation’s research center for bioenergy, I can assure you that a sustained, high-level of investment for research in bioenergy will provide major benefits for future generations. We need to keep apace with this work because biofuels are an environmentally and economically beneficial way to bridge the gap between rising energy demand and peaking oil production, while reducing U.S. dependence on imported oil.